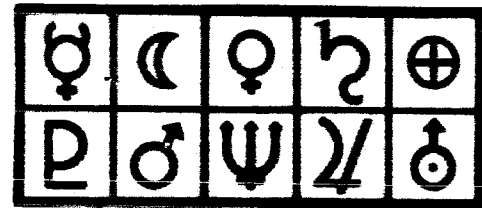


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for

Period Ending June 30, 1966

Planetary Quarantine Department

Sandia Laboratory, Albuquerque, New Mexico

July 1966

Project No. 340.229.00

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I - INTRODUCTION

The effort undertaken under NASA Contract R-09-019-040 will provide continuing research, development, and engineering services in support of the Planetary Quarantine Program. Initial responsibilities are to include, but not be limited to (1) a general system analysis to investigate the microbiological loading expected on a planetary landing capsule prior to terminal sterilization and (2) development of instrumentation and monitoring techniques for biologically clean assembly rooms. The Lovelace Foundation for Medical Education and Research will support Sandia in the microbiological aspects of the program.

To assist in providing a theoretical foundation for the planetary quarantine problem, statistical models will be derived based on planetary objectives, biological factors, assembly and manufacture work environments, and assembly and manufacture techniques. These models will permit statistical predictions of microbiological contamination on planetary probes and landers and will provide analysis of the interactions of such predictions with the overall planetary exploration objectives.

Verification of the mathematical modeling will require research, development, and engineering support in the areas of microbiology, instrumentation, and monitoring techniques. Consulting services on clean room technology and operations will be provided to NASA centers as requested.

II - SYSTEMS STUDIES ACTIVITIES

The general objective of the Systems Studies Division is the development of an operational program based on quantitative models, which if followed, would lead to the achievement of stated planetary quarantine objectives. We have been engaged in three specific areas of activity this quarter:

- (A) A general survey of program development (Report expected late September).
- (B) A modification of the Coleman-Sagan model (Report expected early August).
- (C) A stochastic assembly model (Report in press).

The remainder of this section is devoted to a discussion of the progress made in each of these areas.

(A) General Survey of Program Development

The Systems Studies Division is undertaking a survey of available literature pertinent to the area of program development. Our objectives are:

- (a) to formulate an overview of a program at an abstract general level,
- (b) to determine general areas in need of development,
- (c) to outline specific problems arising in pursuance of this development, and
- (d) to model these problems insofar as manpower and time permits.

Such an activity cannot be considered complete, of course, until a completely operational planetary quarantine program has been formulated. A brief description of our current overview of the program is given below.

The program may be viewed as falling into five general categories:

- (1) planetary
- (2) in transit
- (3) sterilization
- (4) assembly
- (5) manufacture.

The objectives of planetary exploration are essentially planetary in character. That is, they belong to the first program category because they are objectives stated explicitly in terms of the planet and are quite unrelated to a procedural means of achieving them. Coleman and Sagan made an attempt to relate these abstract objectives to requirements on the spacecraft, thereby generating new subobjectives which are more nearly operational than the program objectives. Their work has been discussed and revised by numerous persons, and a wholly satisfactory model has not yet been obtained. Nevertheless, it seems very likely that a satisfactory model will lead to requirements on σ , the expected number of microorganisms per spacecraft upon contact with the planet.

In category (3), sterilization, one is concerned with the development of a model in which σ' , the expected number of microorganism per spacecraft after the terminal sterilization cycle on earth, is predicted as a function of the time and temperature of the heat cycle and the number, n_0 , of microorganisms present on the spacecraft prior to terminal sterilization. Although the standard exponential death process model is frequently used for this purpose, there is experimental evidence of "tailing", indicating that some alternative model may be necessary. Further experimentation seems indicated.

In the in transit program category, one's primary concern is the relation between σ , the expected number of microorganisms per spacecraft on the planet, and σ' , the expected number of microorganisms per spacecraft on earth. This concern is necessitated by the possibility that microorganisms will be transferred from the unsterilized shroud exterior to the sterilized lander during shroud separation. Although it is a vital area in program development, no work of this nature has been done.

The objective in category (4), assembly, is the development of a model by which n_0 , the number of microorganisms on a spacecraft prior to terminal sterilization, may be predicted. This is necessary because n_0 will almost certainly be a required input for the sterilization model. Two models exist (one deterministic, the other stochastic), but both suffer from generality. That is, neither is developed in sufficient depth to allow operational requirements to be formulated directly from them. A great deal of experimental data is available in this area, and modeling activity is being undertaken by several organizations.

The results obtainable from an assembly model will almost certainly depend upon the contamination of the initial parts to be assembled, and the amount of this contamination just prior to assembly will be a function of manufacturing and initial assembly (acceptance) procedures. Almost nothing has been done in the way of predictive modeling in this area although a certain amount of experimentation has been performed.

From this overview, it seems apparent to us that there are many areas in need of development. Activities (B) and (C) discussed below have been aimed at modeling some of the more obvious problems arising in these areas.

(B) A Modification of the Coleman-Sagan Model

From a program development point of view, the model of Coleman and Sagan was an attempt to relate total planetary mission objectives to hardware requirements for planetary quarantine. There are several objections to this model, including, some misunderstanding of the parameters used in the model (which have not been fully resolved in subsequent treatments) and the assumption that one is able to fly infinitely many missions to achieve his overall exploration objective. This latter assumption allows one to derive a requirement on σ , the expected number of microorganisms per spacecraft upon impact with the planet, regardless of the probability of success of each of the flights, P_s . That is, while σ is a function of P_s , for any given P_s it is possible to determine a value of σ which will allow the total exploration program's objectives to be met. This is not the case when some maximum, finite, number of flights is contemplated.

Recent modifications of Coleman and Sagan's model have overcome this last objection to some extent, by considering only a finite number of flights. However, such models, without further analysis of the number of flights chosen, are essentially ignoring total exploration objectives and considering only sterilization objectives. This could prove to be unreasonable since there is a definite, and as yet not thoroughly analyzed, relationship between sterility requirements and reliability requirements when only a finite number of missions are flown. Using a computer and treating many of the quantities as parameters, preliminary calculations dealing with this relationship have been obtained.

A complete report of this work along with a clarification of the meaning of some of the parameters appearing in recent reports is expected sometime early in August.

(C) A Stochastic Assembly Model

A model has been developed and refined which treats the assembly problem stochastically. There are two types of stochastic elements in the model: (i) the amounts of contamination on parts and subassemblies,

and

(ii) the distribution of contamination on the surfaces of the parts.

The latter is considered because of the possibility of different chemical decontamination results on different types of surfaces.

The report is in press. Entitled, "An Assembly Contamination Model," it will be available as Sandia Corporation Research Report No. SC-RR-66-421.

III - SYSTEMS SUPPORT ACTIVITIES

The general objectives of the Systems Support Division are:

(1) to support the Systems Studies Division by gathering experimental data for the purposes of (i) establishing parameter values for theoretical mathematical models and (ii) assistance in realistic model development so that the model represents the achievable and can later be reduced from theory to practice with minimum difficulty; (2) to assist NASA with Clean Room design and clean room requirements for check out and operational procedures. Pursuant to these objectives, the following specific areas of activity have been engaged in this quarter:

- (A) Design for a high rate aerosol particle sampler
- (B) Study of fine particle behavior on surfaces
- (C) Assistance to NASA in clean room design and clean room requirements

The remainder of this section is devoted to discussion of the progress made in these areas.

(A) Design for a High Rate Aerosol Particle Sampler

Until recently sampling for airborne particles in clean rooms has been a matter of measuring high concentrations of such particles. With the development of much cleaner areas, a need has arisen to measure very low concentrations of airborne particles. The common method for measuring or counting airborne particles is that of measuring light scattered from airborne particles. Sampling rates (approx. .01 cubic ft. per minute) were kept small to avoid coincidence problems in the sensing zones.

To more accurately evaluate very clean areas, larger air samples must be taken. The coincidence problem is lessened in very clean areas;

however, optical systems must be improved to illuminate larger sensing zones, and air handling methods must be improved.

A developmental device has been designed and constructed at Sandia to sample one cubic ft. per minute. This unit is a laboratory type unit; however, results obtained from this unit proved the practicability of the idea for standard production counters.

This unit showed much better sensitivity for low concentrations of airborne particles than present counters; counting concentrations as low as 5 to 10 particles per cu. ft. reliably compared to 1000 for present type counters. (0.5 micron size and larger total).

Repeatability was better than 2%, even for the low concentration levels.

The unit also has a much improved capability of counting large particles such as clothing fibers and other process generated particles. This capability makes the unit useful for evaluating spot location conditions.

As time permits, a unit is being designed to sample 2 to 5 cubic ft. of air per minute. Some sacrifice in unit size may be necessary for units that sample over 5 cu.ft.min. due to requirements for larger optical systems.

A technical report on this work is being prepared as a Sandia Corporation Research Report and will be published in August.

(B) Studies of Fine Particle Behavior on Surfaces

These studies are being conducted to develop information concerning particle collection, retention, and removal for flat as well as irregular surfaces. They will, hopefully, yield realistic numbers for use in the mathematical models for the planetary quarantine program. One phase of this work has been oriented toward a study of loose dry particles on flat surfaces. This study is well underway and a preliminary progress report is under preparation for publication in August. Another study underway concerns the development of means of controlling airflow to limit particle deposition on sensitive surfaces, which involves clean room design, layout, procedures, etc. A research report, SC-RR-66-385, "An Evaluation of Clean Up Efficiency for Viable Contamination by a Class 100 Laminar Flow Clean Room" is in printing and will be distributed in early August. Another supporting report SC-RR-66-386, "The Deposition of Nutrients to Surfaces by Rodac Plates" will be distributed at the same time.

(C) Assistance to NASA in Clean Room Design and Clean Room Requirements

Assistance to NASA was provided in clean room design and clean room requirements for installations at Cape Kennedy (hydraulic assembly building, Merritt Island), JPL, Goddard Greenbelt, MSC Houston, and the Phoenix Field Station USPHS. Work consisted of consultation and recommendations on final drawings, bid request specifications, filter test specifications and check out procedures.

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